JOINT PANEL

ON

OCCUPATIONAL AND ENVIRONMENTAL RESEARCH

FOR URANIUM PRODUCTION IN CANADA

1986 ANNUAL REPORT

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Research for Uranium Production in Canada

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FOREWORD

1986 Annual Report of the Joint Panel

I am pleased to submit the 1986 Annual Report of the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada.

Meetings of the Panel members, with technical sessions and field visits, provide a means of bringing together specialists with common concerns. Formal working groups have been set up to deal with identified problems. Other collaborative efforts have arisen among member agencies and companies. These efforts lead to the dedication of research capacity to the health and safety of workers and control of the environment.

Although the recent economic situation has led to a slowing down of research activities relating to uranium mining, and to some reduction in support for the work of the Panel, your executive has received some very positive comments about the quality of our recent meetings, and about the value to members of our Annual Report. We are determined to maintain, and if possible improve upon, this quality and we would like to appeal to all Panel members to help in this by attending meetings whenever possible. We would also welcome all comments or suggestions from Panel members for possible topics and speakers for meetings, or for any other way of helping to make our meetings of greater value.

The Panel wishes to thank Environment Canada, and Indian Affairs and Northern Development for hosting the 1986 sessions of the Panel.

Also, the Panel gratefully acknowledges the contribution of the Mining Research Laboratories (CANMET) for publishing this report and providing the services of R. Tervo as Secretary.

L.D. Brown
Chairman

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

EXECUTIVE - 1986

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Provincial Agencies Representative: Dr. L.D. Brown, Saskatchewan Labour.

Federal Agencies Representative*: Dr. J. Bigu, CANMET, EMR Canada.

Union Representative*: Mr. H. Seguin, USWA.

SUPPORTING MEMBER ORGANIZATIONS, 1986

Atomic Energy of Canada Limited (AECL)
Atomic Energy Control Board (AECB)
Canadian Institute for Radiation Safety (CAIRS)
Denison Mines Limited (DEN)
Eldorado Resources Limited (ERL)
Energy, Mines and Resources Canada (EMR)
Environment Canada (DOE)
Health and Welfare Canada (NHW)
Indian Affairs and Northern Development Canada (DIAND)
Key Lake Mining Corporation
Ministry of Labour, Ontario (MOL)
Rio Algom Limited (RIO)
Saskatchewan Environment (SE)
Saskatchewan Labour (SDL)
Saskatchewan Mining Development Corporation (SMDC)
United Steelworkers of America (USWA)

ASSOCIATE MEMBER ORGANIZATIONS, 1986

Cigar Lake Mining Corporation, Saskatchewan
Department of Consumer Affairs and Environment, Newfoundland and Labrador
Department of Mines and Energy, Newfoundland and Labrador
Department of Mines and Petroleum Resources, British Columbia
Labour Canada

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* See membership list, page 44, for addresses and telephone numbers.

Mines Accident Prevention Association of Ontario
Ministry of the Environment, Ontario
Ministry of Natural Resources, Ontario
Saskatchewan Research Council
Saskatchewan Mining Association
Technical Advisory Committee on the Nuclear Fuel Waste Management Program
Uranerz Exploration and Mining Limited

JOINT PANEL ACTIVITIES - 1986

Two regular business meetings were held during 1986.

1. May 28-29, 1986, Saskatchewan, Sask.

On May 28th, the Joint Panel met in Saskatoon with Dr. D. Lawson, Environment Canada, Regina, acting as host.

The business meeting was held on the morning of May 28th with twenty-three people in attendance representing seventeen agencies or companies. The technical session was held that afternoon with four presentations:

Dr. Don Waite: Environment Canada - Regina
"Radionuclides, Langley Bay, Lake Athabaska, (near Gunnar Mine)".

Dr. John Sheard: Biology Dept., University of Saskatchewan
"Distribution of radionuclides in Northern Saskatchewan and adjacent N.W. Territories, (Rabbit Lake, Cluff Lake, Uranium City)".

Mr. Tom Hynes: (AMOK) and University of Saskatchewan
"Effects of uranium milling effluents on the aquatic eco-system (Cluff Lake)".

Dr. Stella Swanson: Saskatchewan Research Council
"Laboratory study plan for the effects of radionuclides on aquatic fauna".

(Note: All of these studies have had the support of Environment Canada).

Field trip to Key Lake Mining Corp. May 29th.

A full day at Key Lake was enjoyed by fourteen members of the Panel. Thanks are offered to Saskatchewan Mining Development Corporation for sponsoring the trip and making all arrangements, and to Key Lake Mining management and staff for conducting the tour of their facilities.

The Joint Panel Executive recommended a four year term for members of the Executive. This was approved by the members and the terms of reference now show this change.

2. November 25-26, 1987, Hull, P.Q.

The fall meeting was held on November 25-26th in Hull, P.Q. with Dr. M. Barnett, DIAND, acting as host. Ten people were in attendance at the business

meeting representing seven agencies or companies.

The technical session on 26th November was attended by eighteen people. Three presentations were made:

M.K. Woo: McMaster University
"Modelling of tailings in a permafrost environment".

J. Bigu: CANMET, EMR Canada
"The National Radiation Instrumentation Calibration Facility at the Elliot Lake Laboratory - a preview".

L. Price: Key Lake Mining Corporation
"Historical review of the South Dakota train-truck collision and yellowcake spill".

REPORTS BY WORKING GROUPS

Active and proposed working groups include:

Internal Dosimetry
Personal Dosimetry
Occupational Hazards
High Grade Ores

The Internal Dosimetry working group presented their report last year. Members were asked to comment. If a vote of accceptance is passed by the members at the June 1987 meeting, it is proposed to publish this report as a Joint Panel document.

The Personal Dosimetry program at Rio Algom Ltd. was reviewed by J. Bigu at the November 1986 meeting. The dosimetry data did not correlate well with the data from grab sampling during that period. A similar disagreement was reported by P. Duport from comparison tests in France. For Personal Dosimetry this was the final report.

Working groups have been proposed for occupational hazards and high grade ores. No progress has been reported on occupational hazards and a group has not been organized for high grade ores.

ACTIVE RESEARCH PROJECTS

ATOMIC ENERGY OF CANADA LTD. (AECL)

Environmental Effects

101. Environmental pathways analysis - Aquatic (Chalk River).

102. Environmental pathways analysis - Terrestrial (Pinawa).

103. Environmental pathways analysis - Effects of water flow on sorption of radionuclides (Pinawa).

104. Experimental pathways analysis - Sorption of nuclides onto geologic material (Pinawa).

105. Effect of groundwater components on UO_2 dissolution (Pinawa).

106. Actinide - rock interaction (Pinawa).

107. Environmental impact and stabilization of naturally radioactive wastes (Chalk River).

Assessment of Radiation Hazards

108. Quantification of radiation risks (Chalk River).

Radiation Dosimetry

109. Radiation dosimetry and instrumentation development (Chalk River).

110. Internal dosimetry modelling (Chalk River).

111. Deposition of attached and unattached radon daughters (Chalk River).

Assay Methods

112. Bioassay of actinides (Chalk River).

113. In vivo monitoring (Chalk River).

HIGHLIGHTS OF AECL'S RESEARCH ACTIVITIES - D. Myers

Environmental:

Surface Water Transport - Activity balance models are generally applied to prediction of radionuclide behaviour in lakes. The successful application of such models relies upon the use of realistic rate constants to describe the various processes affecting transport. Significant differences have been observed in these rate constants when derived from mass balance studies on lakes (long-term studies) versus short-term tracer addition experiments. Recently, tracer addition experiments (in in-lake limnocorrals) have been carried out at the Chalk River Labs of AECL to determine the reasons for, and significance of, these differences. Several parameters were evaluated: seasonal fluctuations in hydrology, different modelling methodologies, changes in the chemical form of the radionuclides, time variant geochemistry, resuspension from sediments, and diffusion or back-diffusion between waters and sediments. Based upon a preliminary analysis of the results of these experiments and comparison with computer simulations and several other recent studies the diffusional processes appear to be most significant in explaining the differences.

Natural Analogs to a Disposal Vault - AECL has a program underway to study deep uranium deposits as analogs for a high level waste disposal. Current work is focused on the Cigar Lake uranium deposit in Saskatchewan. Analyses of the water chemistry and microbiology, and the mineralogy of the site is underway in an effort to define the probable evolution of the deposit. Assessment of the implications, of the data gained, for predicting the future behaviour of releases from a disposal vault is the ultimate objective of the

study.

EXTERNAL ACTIVITIES

P.J. Barry represented AECL at a meeting of BIOMOVS (Biosphere Model Validation Study), a Swedish based pilot study whose objective is to intercompare and validate models. Test scenarios have been set up for atmospheric, terrestrial and aquatic models for biosphere processes. As an example 8 models were applied to predicting ^{226}Ra and ^{230}Th concentrations in sediments, fish and water with time, and predicted concentrations varied by three orders of magnitude. The results illustrate that significant progress is required before effective ways of intercomparing and validating models are put in place. The group is also evaluating the monitoring results that will be available from the Chernobyl accident and their possible use for model validation.

Several Canadian scientists, including two from AECL, participated in the annual meeting in Vienna of the United Nations Scientific Committee on the Effects of Atomic Radiation. Three reports on genetic effects of radiation, dose response relationships for radiation-induced cancer and the effects of irradiation in utero were prepared in final versions for publication in 1986. Considerable progress was made in the preparation of other reports for publication in 1988. Environmental effects of radiation was added to the list of topics to be considered.

A report on radiological implications of the Chernobyl accident was prepared for the AECL Chernobyl Task Group. Increments in radiation exposures of the Canadian public were much too small to have any appreciable impact on the future health of Canadians.

During 1986, work on the ICRP Task Group on Lung Model continued. It is expected that a new lung model will be submitted to the ICRP for their review by the end of 1987, or early 1988. Work also continued on the Federal - Provincial Working Group's Guideline on Uranium Bioassay, and the NCRP's Bioassay Guideline was amended to take into account comments from external reviewers. It is expected it will be published in 1987.

ATOMIC ENERGY CONTROL BOARD (AECB)

202. Ontario miners mortality study (Phase II) (OML, WCB).

203. Newfoundland Fluorspar Miners Statistical Mortality Study (Statistics Canada, NHW).

204. Ontario Miners "Alive" Follow-up Feasibility Study.

205. Ecological Dynamics of Uranium Mill Tailings, IV.

207. Epidemiological study of lung cancer mortality in Canadian mining communities.

208. Ontario miners SIN evaluation study.

209. Study of the Health Effects of Inhaled Radioactive Dust.

210. The Canadian National Dose Registry Study.

213. Duration of Release Limits for a Typical Mining Facility.

214. Bioassay Techniques for Saskatchewan Workers.

218. Epidemiology of Lung Cancer in Canadian Mining Communities.

219. Measurement of the Thickness of Bronchial Epithelium.

220. Ontario miners morbidity follow-up feasibility study.

221. Study of the Size Change of Inhaled Submicron Aerosols.

222. Comparison of the Techniques Used in Estimating Past Exposures to Radon Daughters in Canadian Mines.

225. Determination of concentration factors - game animals.

227. Characterization of Long-Lived Dust at a Saskatchewan Mine Mill.

228. Movement of Radionuclides Between Water and Sediments.

229. The Waste Management Implications of Concentrating Slimes - II.

230. Laboratory System for Alpha-Particle Spectroscopy.

232. Determination of Radon and Thoron Fluxes in Uranium Mines (Ontario).

233. Determination of Radon Flux in Uranium Mines (Saskatchewan).

234. Calibration of Wire Screen Collectors in the Measurement of the Unattached Fractions of Radon and Thoron Progeny in Air.

235. Modified Personal Alpha-Dosimeter for Canadian Uranium Miners.

236. Survey of Data on the Radionuclide Content of Fish.

237. Adapting Dosimetric Models for Use on AECB Electronic Data Processing Systems.

HIGHLIGHTS, RESEARCH & DEVELOPMENT, ATOMIC ENERGY CONTROL BOARD - H. Stocker

Since the previous meeting of the Joint Panel (May 28, 1986) eight research projects have been completed and seven reports have been published. The published reports cover topics that range from the investigation of physical characteristics of long-lived dust, uranium concentrates, and uranium compounds (INFO-0167-1,2, INFO-0205), to analyses of techniques and instrumentation for measuring exposure to various radio-aerosols (INFO-0184, INFO-0187). In addition, three reports on the management of uranium tailings areas have been published (INFO-0182, INFO-0195-1, INFO-0198). The eighth report that has been completed, "Development of an Automated Method for Determination of Thorium in Soil Samples", is in the process of publication.

The study "Determination of the Contribution of Respirable Long-Lived Dust to Lung Exposure in the Uranium Industry", found AMAD values ranging from

5 to 10 μm in underground mines, and 7 μm in mills. The variability of air concentration and dimension of the long-lived dust led the authors to suggest the need for continuous personal monitoring devices to determine individual exposures to long-lived dust.

The study to investigate the feasibility of determining the dissolution rates of uranium ore dust, uranium concentrates and uranium compounds in simulated lung fluid has resulted in the design of a flow-through apparatus for the purpose of solubility measurement. A full scale study is currently under consideration.

An extensive review of the recent literature concerning passive radon daughter dosimeters and interviews with scientists working in the field of dosimeter development has led the contractors to conclude that currently a passive radon daughter dosimeter that is suitable for use in a mine does not exist, and that there is little hope for the development of such a device. The contractors also express pessimism regarding development of 'semi-passive' devices.

Measurements of unattached fractions, aerosol size and activity distributions, obtained in Elliot Lake uranium mines in Jan./Feb. 1985, have shown:

a) a weak bimodal activity distribution for aerosols for which there is up to a 10% unattached fraction;

b) unattached fraction determinations based on gross alpha-counts are more accurate than those based on radionuclide concentrations calculated from the filter activities;

c) unattached fractions determined from wire screen and reference filter measurements are smaller than those determined from counts on the reference and back-up filters; and

d) theoretical determination of the unattached fraction is very sensitive to the age of the air, especially for relatively young air (age less than 20 min).

The study "Doses Resulting from Intrusion into Uranium Tailings Areas" found that, using reasonable intrusion scenarios and realistic exposure conditions, the annual doses resulting from recreational and construction activities would be generally small (smaller than 20 mSv), while habitational and agricultural activities could result in annual doses to individuals of several hundred millisieverts.

The report "Waste Management Implications of Concentrating Slimes", describes the geotechnical, geochemical, and environmental characteristics of fine-grained uranium tailings (slimes) which may influence both short- and long-term management of slime-enriched uranium tailings impoundments.

The report "The Cost of Decommissioning Uranium Mill Tailings", identifies several key operations that are commonly carried out during decommissioning of tailings areas, and costs these operations for a generic site, to provide a 'base reference case'. The report also recommends a generic monitoring regime upon which both short- and longer-term environmental monitoring costs are calculated.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS)

HIGHLIGHTS OF CAIRS ACTIVITIES - E. Becker

301. Training - A contract was awarded by the Atomic Energy Control Board in January, 1987, for CAIRS to develop the first of a series of radiation safety training modules. The training is aimed at uranium and other miners, but can be adapted to non-mining occupations.

302. Lung Cancer Detection - A seminar to review the CAIRS Lung Cancer Detection Program was held in Toronto in February, 1987. Enrolment in the program has tripled over the past two years. As of May, 1987, 1400 Elliot Lake uranium miners have participated in the sputum cytology program, which is free to them, voluntary and confidential.

303. Personal Alpha-Dosimeters - Field testing of a modified version of a French personal alpha-dosimeter has started in one of the Saskatchewan uranium mines. The original dosimeter, imported from the French Atomic Energy Commission, has been used in the CAIRS dosimetry program for the past four years. An AECB contract is funding CAIRS' work to modify the dosimeter to make it suitable for Canadian mining conditions. CAIRS and the French Atomic Energy Commission (CEA) are cooperating in the development and testing.

Radon in Homes - CAIRS is monitoring radon levels in 838 Elliot Lake homes under a contract awarded by the Ontario Ministry of Labour. The project is a follow-up to previous monitoring programs and will be completed in June, 1987.

DENISON MINES LIMITED (DEN)

302. Sputum cytology, Ontario uranium mines (see CAIRS, RIO, USW).

418. Thickened tailings experiment for close-out of uranium mill tailings at Denison Mines Ltd.

419. Hydrogeochemical investigations at two inactive tailings areas at the Williams Lake and Stanrock management sites, complementary to studies by Rio Algom, CANMET and University of Waterloo.

As noted in the EMR Highlights, collaborative studies of the underground environment are being conducted on a regular basis.

ENERGY, MINES AND RESOURCES CANADA (EMR)

500. Instrumentation development (to improve and standardize radiation measurement techniques). (DEN,RIO).

501. Environmental radon (thoron) daughter and radioactive dust level determination. (DEN,RIO).

502. Control strategy development (to identify radon and thoron sources and

evaluate control techniques at Canadian uranium mines using continuous monitoring techniques. (DEN,RIO).

503. Development of techniques for assessment of air, water and soil contamination by uranium mine tailings areas (includes characterization of tailings and soil profiles). (RIO,DEN).

HIGHLIGHTS OF EMR'S ACTIVITIES - J. Bigu

The objectives are: to develop radiation instrumentation and to undertake studies to determine radiation levels produced in various mining operations: to identify the major factors affecting the release of radioactive products in mine air; and to develop control methods capable of reducing radiation to acceptable levels.

Instrument Development and Technical Evaluation

A contract for the development of a radon daughter/thoron daughter personal dosimeter of the active kind awarded to Thomson and Nielssen (Ottawa) has been completed. The dosimeter can also operate in a passive fashion. This instrument uses semiconductor IC memory technology, i.e., Dynamic Random Access Memory (DRAM) units to count and store α-particles. The first prototype has been delivered to the Elliot Lake Laboratory (March 1986). An underground technical evaluation of the instrument has been conducted, and the results have been presented at an International Conference (Pittsburgh, May 1986). The dosimeter will also be thoroughly tested in the new radon/thoron test facility (RTTF).

The results of a personal α-dosimetry program at Rio Algom Ltd. during the period 1983-1985 have been analyzed. The dosimetry program was carried out at two Elliot Lake mines. Both mines used the CEA track-etch dosimeter. A reduced dosimetry program at Panel Mine was also conducted using the Alpha-NUCLEAR personal dosimeter.

The Elliot Lake Laboratory has conducted the analysis of the data in collaboration with local mine technical staff. Some of the results obtained were presented at the Joint Panel meeting in Hull, Quebec, 25-26 November, 1986.

National Radon/Thoron Test Facility (RTTF)

A radon/thoron test facility (RTTF) to be used as the national facility for testing and calibrating radiation instrumentation used for AECB compliance purposes and other purposes, has been installed at the Elliot Lake Laboratory. Full operation of this facility is expected sometime in 1986/87, when construction problems have been overcome.

The RTTF will make available a wide range of operating conditions such as:

1. Radon, thoron and arbitrary mixtures of both:

2. Radon daughters, thoron daughters and arbitrary mixtures of both:

3. Variable temperature;

4. Variable relative humidity;

5. Variable aerosol type, concentration and size distribution;

6. Variable air flow rate;

7. Capabilities have been provided for injecting long-lived radioactive dust to simulate underground uranium mine atmospheres. However, no instrumentation for this purpose has been acquired because of lack of funding. The same applies to gas chromatography to measure tracer gases used in plate-out studies, and air residence measurements.

In addition, the RTTF can be operated in either a flow-through or in a recirculating mode. Special provisions are being made to allow for automatic, unattended, control of the radiation level by means of a computer system, dedicated sensors, and a specially developed software package.

Environmental Radiation Level Determination

A long-term research program aimed at determining long-lived radioactive dust (LLRD), and other radioactive dust (RD), in general, in underground uranium mines and mills is in progress. Thus far, this program has been confined to a small number of locations, mines and mining operations. Because LLRD and RD have become important in radiological protection and health physics, the importance of their characterization and quantification cannot be stressed adequately. CANMET proposes to extend studies of LLRD and RD to other Ontario and Saskatchewan uranium mines and mills, in collaboration with interested mining companies.

Recent studies have been conducted on a conveyor belt and a crusher at an Elliot Lake mine as part of a Radiation/Respirable Dust/Ventilation program. Further studies have been carried out at a uranium mill in Saskatchewan under AECB financial assistance. More recently, LLRD and radiation studies have been undertaken at Elliot Lake in conjunction with the installation of a water scrubber at the crusher/conveyor belt, where previous measurements were conducted for control purposes.

Long-lived radioactive dust measurements carried out to date include concentration, size distribution, activity level, MMAD and AMAD. Identification has been carried out by means of α-spectroscopy, γ-spectroscopy and fluorometry. The above variables permit the exposure risk from this radiological hazard to be estimated. This work is, therefore, of great practical interest from the radiological protection point of view.

A major study aimed at investigating the relationship between radon progeny Working Levels, WL(Rn), and thoron progeny Working Levels, WL(Tn), in underground uranium mines is at present being carried out at Elliot Lake. If a firm relationship between WL(Tn) and WL(Rn) can be established, measurement of WL(Rn) alone could be used to calculate WL(Tn). This procedure would result in considerable savings in manpower and time. Knowledge of WL(Tn) is important to calculate the total health risk associated with personal radiation exposure in uranium mines. Total radiation exposure in uranium mines is composed of the following contributions: radon progeny, thoron progeny, long-lived radioactive dust, and gamma-radiation.

The results of the above investigation will be compared with data

collected since 1979, the year when a systematic study of this problem was initiated by the Elliot Lake Laboratory radiation group. Several thousand measurements of WL(Rn) and WL(Tn) have been carried out during the period 1979 to 1986.

The study on WL(Rn) and WL(Tn) indicated above will be complemented by an investigation, in a local underground uranium mine, of 'overall average' radon and thoron source terms determined from direct experimental measurements aided by a theoretical radiation mine model developed at the Elliot Lake Laboratory and measurement of air residence time by tracer gas techniques.

Underground Environmental Monitoring and Control Program

Radiation, respirable dust and ventilation are three research areas relevant to underground uranium mines. The Elliot Lake Laboratory has recently undertaken a series of combined studies on these areas in collaboration with the local underground uranium mines at Elliot Lake. At present the following items are being studied.

1. Characterization of airborne, and coarse, non-radioactive and radioactive dust, i.e., type, concentration and size distribution, as related to underground mining operations such as mucking, slushing and rock fragmentation;

2. Optimization techniques to control and/or minimize production of dust, diesel particulates and radiation underground;

3. Development of radiation/airborne particulate/ventilation model(s) and dust/ventilation model(s), and verification of these models by field experimentation and ventilation surveys;

4. Radiation studies leading to better understanding of bacterial leaching;

5. Evaluation of personal α-dosimeters and dust instrumentation underground.

An investigation to estimate air residency times by conventional tracer gas analysis and by radiation techniques has been completed at an Elliot Lake mine in stopes where flood leaching is currently being practised. Another study to determine the effect of a charged water-spray system on respirable dust, LLRD, and radon and thoron progeny activity concentrations underground has recently been completed.

A study to evaluate the performance of a wet scrubber in an underground crusher/conveyor belt area for dust and radiation control purposes has been completed. The study showed a significant reduction of both variables when the wet scrubber was in operation.

An extension of some of the above items to other uranium and non-uranium mines is being considered.

TAILINGS MANAGEMENT TO MINIMIZE ENVIRONMENTAL IMPACT - by N.K. Dave & T.P. Lim

The project element objective is to develop methods of tailings disposal and surface stablization of inactive tailings piles to reduce the detrimental effects of contaminant transport via wind and water erosion, surface run-off and groundwater infiltration as a subsurface seepage. While

major studies are now being done on sulphide tailings areas, the results will be relevant to all acid-generating tailings piles.

NATIONAL URANIUM TAILINGS PROGRAM - R. John

Disposal Technology	1708 Consolidation
	1732 Dust (Gunnar)
	1733 Sulphide oxidation
	1730 Disposal technology.
Measurement	1710 Radium dissolution
	1718 SIMS
	1723 Thorium geochemistry
	1724 Biosphere project
	1725 Bacterial study
	1726 Thorium analyses
	1727 Ni/As chemistry
	1734 Tech Edit. French Analytical Manual
	1712 Oxidation limits
	1736 Ni/As Chemistry, II

STATUS OF THE CONTRACTS

Modelling

SYVAC/UTAP (Phase III) Comparison II - The intercomparison of SYVAC and UTAP at Phase II proved very useful. This new contract will make a similar comparison, but with the final Phase III model. Whiteshell Nuclear Research Establishment (WNRE) are currently writing code specifications for SYVAC, from the Phase III model description.

Phase III - The Phase III development work is complete and the full documentation (four volumes) is available.

Arsenic and Nickel Modelling - This work is complete and the report has been issued.

Optimization - This is a joint project with the Atomic Energy Control Board to develop an understanding of the technique for selecting the optimum close-out option.

Peer Review - A skilled technical team will do an independent peer review of UTAP.

Disposal Technology

Consolidation - Work has been completed and the final report will be available soon.

Dust Study - Work was done to complement data collected at Gunnar. Samples were taken satisfactorily and are now being analyzed.

Sulphide Oxidation - This contract was intended to establish the effectiveness of various cover types in preventing the diffusion of oxygen and thus the oxidation of sulphur. The contract was not issued, but may be re-issued

as a laboratory investigation.

Disposal Technology Manual - This contract was awarded to Steffen, Robertson and Kirsten and work started. The initial project meeting was held in September and a field trip to two operating mines was made in October. Completion is scheduled for March 1987.

Measurements

Radium Dissolution - the contract is finished and the report is available.

SIMS - the contract is finished and the contract report is available.

Thorium Geochemistry - work has been completed and a seminar was scheduled for early November. The report will be available.

Biosphere Project - work is completed and the report will be available soon.

Bacterial Project - the work has been done and the report is available.

Nickel and Arsenic Investigations - The work is complete and the report and an addendum of further studies will be available in early 1987.

French Analytical Manual - this has been translated and is undergoing technical review. This is expected to be completed before the end of 1986 and the Manual should be available before March 1987.

Oxidation Limits - the final report will be available by late November 1986.

NiAs Chemistry - follow up studies of kinetic aspects of nickel and arsenic sediment/water transfer in Moira Lake will be completed and reported by March 1987.

Application of the Uranium Tailings Assessment Program (UTAP)

Lacnor - The contract was let to SENES Consultants Limited on August 20th, 1986. To date, SENES have assembled the data, both from the Lacnor study and the literature, to prepare it for transformation and into computer code input. They have written a specification and objective document outlining the major assumptions, the features of the tailings, the pathways to be considered, the major radionuclides to be included, the receptors to be considered and proposed various technology options. Initial review of the component models, input data required, and test programs have also been completed. They have done some scoping runs with the unmodified UTAP and representative data to ensure that the model outputs are in the correct order of magnitude.

Rabbit Lake - Beak Consultants Limited won the bidding and were awarded the contract on September 2nd. Between Beak and Eldorado they have agreed on a detailed split of the work for model review and data collection. They have established the additional data requirements and plans are in place to take additional samples and analyses. They have also begun the modelling review.

ENVIRONMENT CANADA (DOE)

605. Interactions of radionuclides from abandoned uranium tailings with organic residues.

606. Radionuclide distributions in the vegetation of North Saskatchewan and adjacent North West Territories.

607. Radionuclides in Langley Bay, Lake Athabaska, Saskatchewan (includes 609).

608. Effects of uranium effluents on aquatic ecosystem in North Saskatchewan.

614. A literature review of thorium uptake, retention and secretion.

615. Radioactivity and fish.

HIGHLIGHTS ON SELECTED PROJECTS - P. Vasudev

612. Radionuclide Content of Some Canadian Surface Waters

A National Radionuclide Monitoring Program was initiated to assess the radiological characteristics of surface waters at a limited number of sites across Canada. Most of the sampling stations chosen were in the areas where uranium/coal mineralization has existed and/or nuclear fuel cycle activities were carried out. A few baseline stations were also included in the monitoring network for comparative purposes. In all, 13 locations have been sampled monthly during the four years of operation (1981-1984). The samples were analyzed for uranium, radium-226, cesium-137, antomony-125 and tritium.

Levels of the radionuclides monitored were generally low. Average uranium concentration in these waters ranged from 0.16 to 4.74 μg/L with an overall mean of 1.35 μg/L. The concentration of Ra-226 ranged from 1.43 to 12.67 mBq/L with an overall mean concentration of 3.66 mBq/L. Thus, the concentration of radionuclides (except for uranium at certain locations) in selected Canadian surface waters was below 'Target Concentration' guidelines for Canadian drinking water. Estimates of cumulative dose commitments ranged from 1 to 9 μSv, less than the Great Lakes Water Quality Objective of 10 μSv.

613. Investigation into the Radionuclide Levels in Fish Collected from Port Hope Harbour

Following the completion of the study on the chemical and radiological evaluation of sediments in Port Hope Harbour, further investigations to more accurately determine the radionuclide uptake by fish and the associated human health implications have been initiated. More than 20 fish samples were collected from the Turning Basin of Port Hope Harbour and analyzed for uranium, radium-226, thorium-232, -230, -228 and lead-210 by Environment Canada laboratories in Burlington. Detectable amounts of these radionuclides were found in the samples. Our previous study showed that sediments of Port Hope Harbour contained elevated levels of radioactive and non-radioactive contaminants and it is believed that fish accumulate these contaminants from sediments. While the consumption of fish taken from the Turning Basin is a potential pathway for radionuclide uptake by humans, the estimated dose due to this pathway alone is unlikely to exceed the regulatory dose limit (stochastic) for an individual member of the public. It is also observed that the radionuclide levels in fish tissue are also considerably below those

values reported in the literature as causing an adverse impact on the fish themselves.

615. Radioactivity and Fish

A brochure on this topic is envisaged which is being developed to address a series of questions, viz., what is radioactivity? Where would fish be exposed to radioactivity? How does radioactivity get into fish? Does radiation in fish harm them? Can people eat fish which have been exposed to radioactivity? etc. These questions were arrived at from experience with media interview and discussions in public fora. A literature review will also be included to support the statements made in the brochure. The intent is that the brochure will be made available to the public in English, French and various native Indian Languages.

HEALTH AND WELFARE CANADA (NHW)

703. Bioassay guideline for uranium.

704. Germanium detectors for in vivo measurements.

705. Studies on the solubility of uranium dusts in simulated lung fluid.

HIGHLIGHTS, NHW PROJECTS - M. Limson Zamora

The final draft of the document on a Bioassay Guideline for Uranium has been completed and circulated for extensive external review. Comments were received from members of the uranium-producing community for review at a meeting in December 1986. These comments will be considered for incorporation in the document prior to publication.

The four germanium detectors for in vivo measurements have been received and calibration may proceed.

Some delay was experienced in conducting that part of the project involving the correlation of dissolution properties with particle size of uranium dusts in the respirable range in simulated lung fluid. This study is proceeding.

INDIAN AFFAIRS AND NORTHERN DEVELOPMENT (DIAND)

801. Modelling the effects of uranium mine tailings on a permafrost environment.

802. Pattern of uranium, companion elements and radioisotopes in lichen heath associated with the uranium deposits near Baker Lake, N.W.T. prior to mining operations.

803. Survey of radionuclides in vegetation, soils and sediments of Keewatin uranium mineralized areas.

RIO ALGOM MINES LIMITED (RIO)

850. Surface treatment of tailings.

302. Sputum cytology, Ontario uranium miners.

As noted in the EMR Highlights, collaborative studies of the underground environment are being conducted on a regular basis.

SASKATCHEWAN ENVIRONMENT (SE)

860. Evaluate water quality (ground and surface) in and around 'D' pit (with support from AMOK Ltd).

SASKATCHEWAN RESEARCH COUNCIL (SRC)

912. Compilation and statistical analysis of a data base on uranium-series radionuclides in aquatic biota in northern Saskatchewan (SHRB).

921 Preparation of a brochure and accompanying literature review radionuclides in fish (DOE).

922. Analysis of caribou bones from the Northwest Territories for uranium-series radionuclides, cesium-137 and strontium-90.

923. Development of bioassays for toxicity testing.

HIGHLIGHTS OF SASKATCHEWAN RESEARCH COUNCIL (SRC) - S. Swanson

SRC-22. This project provides data on pre-Chernobyl levels of cesium-137 and strontium-90 in caribou. It also provides data on uranium, thorium, radium-226, lead-210 and polonium-210 levels to be used in relation to results of studies such as Sheard et al. (DOE-29).

SRC-23. SRC is currently developing bioassay capability using micro-organisms (algae and cyanobacteria), invertebrates (primarily Ceriodaphnia) and fish (rainbow trout). These tests can be used to test the toxicity of a wide variety of effluents, including uranium mill effluents.

UNITED STEELWORKERS OF AMERICA (USW)

302. Sputum cytology, Ontario uranium miners.

PROJECTS COMPLETED DURING 1986

See also the publications file for reports on active projects by each agency.

Project Number	Agency	Title	Output
	Atomic Energy Control Board (AECB)		
201.		Determination of the contribution of respirable long-lived dust to lung exposure in the uranium industry. (DEN. RIO).	INFO 0167-1.2
206.		Thoron daughters in an underground mine environment.	INFO 0164
211.		Waste management implications of concentrating slimes	INFO 0195-1
212		Doses resulting from intrusion into uranium tailings areas	INFO 0182
215.		Assessment of passive personal radon daughter dosimeters.	INFO 0184
216.		Electrostatic purification of uranium mine stope atmospheres.	INFO 0173
217.		Feasibility study of the dissolution rates of uranium ore dust, uranium concentrates and uranium compounds in simulated lung fluids.	INFO 0205
223.		In-vivo measurements of Pb-210 in Newfoundland fluorspar miners.	Terminated
224.		The cost of decommissioning uranium mill tailings.	INFO 0198
226.		Analyses of factors affecting aerosol measurements.	INFO 0187
231.		Development of an automated method for determination of thorium in soil.	
	Environment Canada (DOE)		
601.		Leachability of radioactive constituents from uranium mine tailings.	Report
602.		Ecological behaviour of abandoned uranium tailings Phase III.	Report
603.		CRNL hydrology study.	Report
604.		Hydrological research investigations RA7 East Bull Lake	Report
609.		Aquatic pathways of radionuclides released by uranium mining.	Combined 607

610.	Levels and pathways of radionuclides in the Great Lakes.	Project on hold indefinitely
612.	Radionuclide content of some Canadian surface waters.	Report

Saskatchewan Research Council (SRC)

911.	A study of radionuclide transfer in the flooded Gunnar open pit uranium mine.	2 journal articles available from P. Tones
920.	Evaluation of selected aquatic food concentration factors used in the AECL food chain model LIMCAL	SRC Report E-901-6-A-87

DOE-606 Natural uranium radionuclides in the upland vegetation of Northern Saskatchewan and adjacent Northwest Territories. Draft report

TERMS OF REFERENCE

1.0 INTRODUCTION

1.1 The name of the panel shall be "The Joint Panel on Occupational and Environmental Research for Uranium Production in Canada".

1.2 Where appropriate, the name of the panel may be shortened to "The Joint Panel".

1.3 The Joint Panel is a Canadian organization whose members have voluntarily agreed to share information regarding research into the effect of uranium production on the health and safety of workers and the protection of the environment.

2.0 OBJECTIVES

2.1 The primary objectives of the Joint Panel shall be:

(a) identification of those areas related to the occupational health and environmental effects of uranium production in which there is a need for research; and

(b) stimulation of research in areas in which a need has been identified.

(c) the production areas of interest are mining and milling.

2.2 To meet its primary objectives the Joint Panel will:

(a) produce and distribute an annual inventory of current and completed research in relevant areas being conducted by Supporting Members (the Annual Report); and

(b) provide a forum for the exchange and dissemination of information on proposed, current and completed research.

3.0 MEMBERSHIP

3.1 Supporting Membership is open to any organization that actively and continually supports research on the occupational or environmental effects of uranium production.

3.2 Associate Membership is open to those organizations who:

(a) have responsibility or authority relating to occupational or environmental effects of uranium production, but do not actively support research activities; or

(b) are interested in the activities of the Joint Panel, but do not qualify as, or do not wish to become, a Supporting Member.

3.3 Admission to membership in the Joint Panel shall be granted by simple majority vote of the Supporting Members present at any meeting of the Joint Panel.

3.4 Any Supporting Member who is not active in the work of the Joint Panel may be reclassified as an Associate Member by simple majority vote of the Supporting Members present at any meeting of the Joint Panel if such action is requested by the Executive.

3.5 Participation on the Joint Panel will in no way constrain members from pursuing their own organizational or institutional objectives.

4.0 SUPPORTING MEMBER ORGANIZATIONS

4.1 A Supporting Member is expected to contribute to the development of a comprehensive program of research compatible with its roles and responsibilities.

4.2 A Supporting Member is expected to recognize its obligation to make information widely available by:

(a) providing information to the membership of the Joint Panel on current research which they are supporting:

(b) reviewing reports prepared by other Supporting Members and providing comments:

(c) participating in the activities of the Joint Panel.

4.3 A Supporting Member is expected to recognize the need to make final research results available to the membership and to the public.

4.4 Each organization that is a Supporting Member shall designate an individual as its Representative on the Joint Panel.

4.5 Each Supporting Member shall advise members of the Joint Panel of the individual or unit within their organization to which requests for publication should be directed. This information will be included in the Annual Report.

5.0 THE EXECUTIVE

5.1 The affairs of the Joint Panel will be administered by the Executive.

5.2 The Executive shall consist of the Secretary of the Joint Panel and four other individuals. Each of these other individuals must be the designated Representative of a Supporting Member.

5.3 The individuals who are members of the Executive will be chosen to represent four groups that have Supporting Members on the Joint Panel. the four groups being:

(a) The Federal Government;

(b) The Provincial Government;

(c) Industry; and

(d) Labour.

5.4 It shall be the responsibility of each group to select one individual who will represent the group on the Executive. A selected individual shall serve on the Executive for four years from the 1st of January following his selection.

5.5 All decisions of the Executive shall be by consensus. The Executive may decide any matter placed before it on behalf of the Joint Panel.

5.6 Where a consensus on any matter cannot be reached by the members of the Executive, the question shall be referred to the Supporting Members at the next meeting of the Joint Panel, at which time the matter will be decided by a simple majority vote of the Supporting Members present.

5.7 The Executive is authorized to make news releases, in the name of the Joint Panel, from time to time regarding the functioning of the Panel, its role, and the nature and extent of research being conducted.

6.0 THE CHAIRMAN

6.1 The Executive shall select from among its number an individual to serve as Chairman. The selected individual shall serve as Chairman for 1 year from the 1st of January following his selection.

6.2 The Chairman will preside at all meetings of the Joint Panel and of the Executive.

6.3 In case of the absence of the Chairman from any meeting, any other member of the Executive may preside.

6.4 The Chairman, in consultation with the other members of the Executive, shall be responsible for arranging the meetings of the Joint Panel.

7.0 THE SECRETARIAT

7.1 Energy, Mines and Resources Canada (EMR) will provide the necessary Secretariat and publish the Annual Report.

7.2 EMR will appoint an individual to be the Secretary of the Joint Panel.

7.3 EMR may designate the individual who is the Secretary as their Representative to the Joint Panel, or may designate some other individual.

8.0 MEETINGS

8.1 The Joint Panel will meet semi-annually. Normally there will be a Spring meeting (generally in June) and a Fall meeting (generally in December).

8.2 Each meeting of the Joint Panel will include time for:

(a) conducting business relating to the functioning of the Panel;

(b) distribution of information relating to research projects; and

(c) technical sessions.

8.3 Notice of each meeting shall be sent, by the Secretariat, to the designated Representative of each Supporting Member and to each Associate Member. Included with the notice of meeting will be an agenda.

8.4 Attendance at meetings is restricted to designated Representatives of each Supporting Member, and alternates, Associate Members and observers invited by a member of the Executive. However, technical sessions are open to any interested person at the discretion of the Executive.

9.0 RESEARCH REPORTS

9.1 In order to have a common format for research reports, a system of three forms will be used. The forms will be designated as:

(a) FORM 1: STATEMENT OF PROJECT

(b) FORM 2: REPORT OF PROJECT PROGRESS

(c) FORM 3: PROJECT COMPLETION REPORT

9.2 FORM 1 will be used to advise the members of the Joint Panel of any relevant research project which is to be undertaken or which has commenced but has not previously been reported.

9.3 FORM 2 will be used to advise the members of the Joint Panel of any progress that has been made or of any changes of the scope of a project.

9.4 FORM 3 will be used to advise of the completion or early termination of a project.

These three forms are shown in the Appendix.

9.5 A matrix indicating the various areas of active research of interest to the Joint Panel will be maintained, and each project will be identified as to its position on the matrix.

9.6 A similar matrix indicating areas of completed research projects will also be maintained.

9.7 Each project will be assigned a reference number by the Secretariat. Project reports will be identified by this number.

9.8 A summary of the distribution of active research projects on the matrix will be maintained by the Secretariat, and a copy of this summary will be distributed at each meeting of the Joint Panel.

10.0 TECHNICAL SESSIONS

10.1 The technical sessions held at meetings of the Joint Panel will consist of presentations of invited papers, discussions of current

topics and/or field trips.

10.2 It shall be the responsibility of the Executive to organize the technical sessions.

10.3 In selecting papers or topics for presentation at technical sessions, preference will be given to topics related to completed or ongoing research projects.

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

MATRIX OF RESEARCH AREAS

	OCCUPATIONAL	ENVIRONMENTAL
DEFINE CONDITIONS OF EXPOSURE	AECB 201,206,221-2-3, 226-7,232-3-4. AECL 109,112,113 CAIRS 302,303 EMR 501 NHW 705 DEN,RIO,USWA 302	AECB 205,212,228,230-1,236 AECL 101,102 DOE 602-5-6-7-11-15 SRC 912,921,922
IDENTIFY ADVERSE EFFECTS	AECB 218 AECL 110,111,112,113 EMR 550,501	AECL 110,111 DOE 608,615 EMR 500,501,503 DIAND 801,802,803 SE 850 SRC 923
RELATE EXPOSURE WITH EFFECT	AECB 209,210,220 AECL 108,110-11-12-13	AECL 108,110,111 DOE 612,13,14,15 SCR 913
ASSESS RISK	AECB 202-3-4,208,217,219 235,237 AECL 108 DEN 417 RIO 851 USW 990	AECB 225 AECL 101,102,108 DEN 418,419
CONTROL HAZARD	AECB 215,216 EMR 502 NHW 703,704	AECB 211,224,229 AECL 107 DOE 601,602,605 EMR 503 RIO 850

FORM 4/84

PUBLICATION FILE

The first Annual Report of the Joint Panel for Occupational and Environmental Research for Uranium Production in Canada was produced in 1977.

This publication file contains references for only the current year, 1986, and the two preceding years, 1984 and 1985. The annual report for 1983 contains all previous lists of publications, as do earlier annual reports.

Publications should be obtained from the public literature or from the organization conducting or sponsoring the work.

The publication list includes specific project reports by member agencies, as well as other reports of relevance not necessarily associated with the projects listed in the Active Projects section.

ATOMIC ENERGY CONTROL BOARD (AECB) PUBLICATIONS: Listings for 1984.

1. Veska, E., Cherry, J.A., Sharma, H.D., University of Waterloo, "Origin and subsurface migration of radionuclides from waste rock at an abandoned uranium mine near Bancroft, Ontario", (314 p), INFO-0105.

ATOMIC ENERGY CONTROL BOARD (AECB) PUBLICATIONS: Listings for 1985.

1. Phillips, C.R., Khan, A., Leung, H., "Development of diffusion - based radon daughter dosimeters", INFO-0012.

2. R.A.D. Service and Instruments Ltd., "Design of the passive personal dosimeter for mines using an allyl diglycol carbonate plastic - phase I: basic and feasibility study", INFO-0117.

3. Corkill, D.A., Dory, A.B., "A retrospective study of radon daughter concentrations in the workplace in the fluorspar mines of St. Lawrence, Newfoundland", INFO-0127.

4. Chiu, N.W., Dean, J.R., Sill, C.W., "Techniques of sample attack used in soil and mineral analysis - phase I", INFO-0128-1.

5. Archibald, J.F., "Membrane barriers for radon gas flow restrictions", INFO-0130.

6. Friesen, Kaye and Associates, "An evaluation of the uranium mine radiation safety course", INFO-0182,

7. Ching, S.H., "Derived surface contamination limits for the uranium mining and milling industry", INFO-0138.

8. IEC Beak Consultants Ltd., "Probabilistic calculation of dose commitment from uranium mill tailings", INFO-0139.

9. Linauskas, S.H., Kalos, F., "Study of the efficiency and current use of respiratory protective devices", INFO-0144.

10. Senes Consultants Ltd., "Computer modelling of an underground mine ventilation system", INFO-0145.

11. Avadhanula, M.R., "Dissolution studies of UO_2 in simulated lung fluid", INFO-0147.

12. Dean, J.R., Chiu, N.W., "Analysis of techniques of sample attack for soil and mineral analysis - phase II", INFO-0128-2.

13. DSMA Atcon Ltd., "Elliot Lake study: factors affecting the uranium mine working environment prior to the introduction of current ventilation practices", INFO-0154.

ATOMIC ENERGY CONTROL BOARD (AECB) PUBLICATIONS: Listings for 1986

1. DSMA Atcon Ltd., "Comparison of radon and thoron daughter behaviour in two underground uranium mine environments", INFO-0164.

2. Beak Consultants Ltd., "Derivation of release limits for a typical uranium mining and milling facility", INFO-0165.

3. Duport, P.J. and Edwardson, E., Canadian Institute for Radiation Safety. "Determination of the contribution of respirable long-lived dust to the committed dose equivalent received by uranium mine and mill workers in the Elliot Lake area". INFO-0167-1,2.

4. SENES Consultants Ltd., "Electrostatic purification of uranium mine stope atmospheres", INFO-0173.

5. Walsh, M.L., W & W Radiological and Environmental Consultant Services Inc., "Doses resulting from intrusion into uranium tailings areas". INFO-0182.

6. McElroy, R.G.C. and Johnson, J.R., AECL, Chalk River Nuclear Laboratories, "Passive radon daughter dosimeters", INFO-0184.

7. Phillips, C.R. and Khan, A., University of Toronto, "Analysis of factors affecting aerosol, unattached fraction and radon progeny measurements in mines", INFO-0187.

8. Beak Consultants Ltd. and Golder Associates. "Waste management implications of concentrating slimes - characteristics and potential problems", INFO-0195-1.

9. Beak Consultants Ltd., "The cost of decommissioning uranium mill tailings", INFO-0198.

10. Robertson, R., Becquerel Laboratories Inc., "Feasibility study of the dissolution rates of uranium ore dust, uranium concentrates and uranium compounds in simulated lung fluid", INFO-0205.

ATOMIC ENERGY OF CANADA LTD. (AECL): Listings for 1984

1. Werner, M.M. and Myers, D.K., "Biological effects of radiation", Manual for Uranium Mine Radiation Safety Course, Canadian Institute for Radiation Safety, 1984.

2. Kramer, K.G., Johnson, J.R. and Green, W., "The measurement of natural uranium in urine by fluorometry", Report AECL-8251, February 1984.

3. Johnson, J.R., "Age dependent metabolism and dosimetry of bone seeking radionuclides", published in Conf. Proc. of 6th Int. Congr. of the Int. Radiation Protection Assoc., IRPA. West Berlin, pp 485-488, May 1984.

4. Johnson, J.R., Kramer, G.H. and Peterman, B.F. "Internal dosimetry monitoring at the Chalk River Nuclear Laboratories", Published in Conf. Proc. of 6th Int. Congr. of the Int. Radiation Protection Assoc., IRPA. West Berlin, pp 988-991, May 1984.

5. Johnson, J.R. "A review of the dosimetry from inhalation of long-lived alpha activity in ore dust", Published in Conf. Prof. of the Int. Conf. on Occupational Radiation Safety in Mining, Toronto, Ont., October 1984.

6. Myers, D.K. and Johnson, J.R. "Impact of occupational hazards on the life expectancy of uranium miners", published in the Conf. Proc. of the Int. Conf. on Occupational Radiation Safety in Mining, Toronto, Ont. Oct. 1984.

7. Johnson, J.R. and Dunford, D.W., "Canadian uranium fuel fabrication study, Part II: comparison of results of metabolic models", published in Conf. Proc. of the Int. Symp. on the Assessment of Radioactive Contamination in Man, IAEA-SM-276/51, Paris, France, November 1984.

8. Champ, D.R. "Microbial mediation of radionuclide transport - significance for the nuclear fuel waste management program", Report AECL-8566. 1984.

9. Cooper, E.L., McHugh, J.O., "Migration of radiocontaminants in a forested wetland on the Canadian Shield: nuclide speciation and arboreal uptake", in The Science of the Total Environment, vol 28, pp 215-230, 1983.

10. Davison, C.C., Pearson, R. and Whitaker, S.H., "Site investigation methods used in Canada's nuclear fuel waste management program to determine the hydrogeological conditions of plutonic rock", Proc. of IAEA Workshop on Site Investigation and Assessment Methods for Nuclear Waste Disposal, Bulgaria, 1984.

11. Killey, R.W.D., McHugh, J.O., Champ, D.R., Cooper, E.L. and Young, J.L., "Subsurface cobalt-60 migration from a low-level waste disposal site", Env. Sci. & Tech., vol. 18, p 148, March 1984.

12. Killey, R.W.D. and Myrand, D., "The movement of water, arsenic, and radium at a Chalk River waste management area", Report AECL-8639, 1984.

13. Moltyaner, G.L. and Paniconi, C., "Migration of radionuclides in unconsolidated materials: analysis of experimental data", Report AECL-8254.

14. Moltyaner, G.L., "Migration of radionuclides in unconsolidated materials: equilibrium transport models", Report AECL-8253.

15. Osborne, R.V. (Editor), "Long-term radiological aspects of the management of wastes from uranium mining and milling", Nuclear Energy Agency, OECD, Paris, France, 1984.

16. Abdul, A.S. and Gillham, R.W., "Laboratory studies of the effects of the capillary fringe on streamflow generation", Water Resources Research, vol

20, No. 6, pp 691-698, June 1984.

17. Cramer, J.J., "Uranium deposits as analogs to fuel waste disposal vaults", in Proc. of 17th Information Meeting of the Nuclear Fuel Waste Management Program, Ottawa, 1984.

18. Fleer, V.N. and Garisto, N.C., "Mineral stability and thermodynamic models", Proc. of 17th Information Meeting of the Nuclear Fuel Waste Management Program, Ottawa, 1984.

19. Gascoyne, M., "Uranium series disequilibrium studies of shield rocks and groundwater", Proc. of 17th Information Meeting of the Nuclear Fuel Waste Management Program, Ottawa, 1984.

20. Sargent, F.P., "Geochemistry: an overview", Proc. of 17th Information Meeting of the Nuclear Fuel Waste Management Program, Ottawa, 1984.

21. Vandergraaf, T.T., "Radionuclide migration - laboratory studies", Proc. of 17th Information Meeting of the Nuclear Fuel Waste Management Program, Ottawa, 1984.

22. Davison, C.C., "Hydrogeological characterisation at the site of Canada's underground research laboratory", Proc. of Int. Groundwater Symp. on Groundwater Resources Utilization and Contaminant Hydrogeology of the Int. Assoc. of Hydrogeologists, Montreal, Quebec, pp 310-335, 1984.

23. Pearson, R., "An overview of hydrogeological field research in the Canadian nuclear fuel waste management program", Proc. of Int. Groundwater Symp. on Groundwater Resources Utilization and Contaminant Hydrogeology of the Int. Assoc. of Hydrogeologists, Montreal, Quebec, pp 484-497, 1984.

ATOMIC ENERGY OF CANADA LTD. (AECL): Listings for 1985

1. Avadhanula, M.R., Chatterjee, R.M., Healey, G.J., Horvath, F.J., Measures, M.P., Stocker, H., Pomroy, C., Johnson, J.R. and Dunford, D.W., "Canadian uranium fuel fabrication study: I intake, retention and excretion monitoring results. II comparison of results with metabolic models. Symp. on the Assessment of radioactive contamination in man", Intern. Atomic Energy Agency, Vienna, pp. 297-323, 1985.

2. Champ, D.R., Young, J.L., Robertson, D.E., Abell, K.H., "Chemical speciation of long-lived radionuclides in a shallow groundwater flow system", Water Pollution Research J. of Canada, 19, 35-54, 1984.

3. Champ, D.R., Moltyaner, G.L., Young, J.L. and Lapcevic, P., "A downhole column technique for field measurement of transport parameters", AECL-8905, 1985.

4. Davis, J.L., Killey, R.W.D., Annan, A.P. and Vaughan, C., "Surface and borehole ground penetration radar surveys for mapping geological structure", Proc. of the NWWA/EPA Conf. on Surface and Borehole Geophysical Methods, February 07-09, 1984.

5. Jay, P.C., "Anion contamination of environmental water samples introduced by filtration procedures", Analytical Chemistry, v.57, No. 3, pp 780-782, 1985.

6. Jay, P.C. and Judd, J.M., "The determination of common anion concentrations in surface and groundwater samples by eluent suppressed ion chromatography", Intern. J. Environ. Anal. Chem., v.19, pp. 99-109, 1984.

7. Johnson, J.R., "The relative effect of ventilation on the potential α-energy from ^{222}Rn and ^{220}Rn progeny, Health Physics 49, pp 996-998, 1984.

8. LaFleur, D.W., Pickens, J.F. and Killey, R.W.D., "Hydrogeologic assessment of the 233-Lake area: calibration of a 3-D groundwater model", TR-257, 1985.

9. Lee, D.R. "Method for locating sediment anomalies on lakebeds that can be caused by groundwater flow", J. Hydrol. 79, 197-193, 1985.

10. Male, D.H., "Wind transport of soil aerosols", Technical Record, TR-295, 1985.

11. Moltyaner, G.L., Sudicky, E.A. and Cherry, J.A., "Contaminant transport in heterogeneous porous media: characterization of spatial variability and dispersivity at a field site", Technical Record, TR-258, 1985.

12. Munch, J.H. and Killey, R.W.D., "Equipment and methodology for sampling and testing cohesionless sediments", Groundwater Monitoring Review, vol. 5, No. 1, pp 38-42, 1985.

13. Patterson, M.C., Gentner, N.E., Middlestadt, M.V., Mirzayans, R. and Weinfeld, M., "Hereditary and familial disorders linking cancer proneness with abnormal carcinogen response and faulty DNA metabolism", Epidemiology and Quantitation of Environmental Risks in Humans from Radiation and Other Agents, pp 235-267, Plenum Corp., 1985.

14. Peterman, B.F., "Thoron-in-breath monitoring at CRNL", Report AECL-8706, 1985.

15. Olivier, J.P., Osborne, R.V. and Rafferty, P.J., "Long-term management of uranium mill tailings: results of the OECD/NEA study", AECL-8499, 1984.

16. Sheppard, M.I., "Radionuclide partition coefficients in soils and plants and their correlation", Health Physics, 49, pp 106-111, 1985.

17. Sheppard, M.I. and Sheppard, S.C., "The plant concentration factor concept as applied to natural uranium", Health Physics 48, pp 494-500, 1985.

18. Wuschke, D.M., Gillespie, P.A. and Main, D.E., "Second interim assessment of the Canadian concept for nuclear fuel waste disposal. vol. 1 - summary", Report AECL-8373-1, 1985.

ATOMIC ENERGY OF CANADA LTD. (AECL): Listings for 1986

1. Cornett, R.J., Chant, L. and Link, D., "Sedimentation of Pb-210 in Laurentian Shield Lakes"; Water Pollution Research J. of Canada, vol. 19, pp 97-109, 1985.

2. Lee, D.R., "Method for locating sediment anomalies on lakebeds that can be

caused by groundwater flow". J. of Hydrology, vol. 79, pp 187-193, 1985.

3. Champ, D.R., Moltyaner, G.L., Young, J.L. and Lapcevic, P., "A downhole column technique for field measurement of transport parameters", AECL-8905, 1985.

4. Moltyaner, G.L. and Killey, R.W.D., "Field studies of dispersion in porous media: analysis of experimental data", EOS vol 65, p 208, 1984.

5. Munch, J.H. and Killey, R.W.D., "Equipment and methodology for sampling and testing cohesionless sediments", Groundwater Monitoring Review, vol 5, pp 38-42.

6. Zach, R. and Barnard, J.W., "EWAM: a model for predicting food and water ingestion, and inhalation rates of man", AECL-8401, 1985.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS): Listings for 1984

1. Third Annual Report, CAIRS, 1983-84.

2. Radiation Safety Bulletin, vol 2, No. 1, 1984.

CANADIAN INSTITUTE FOR RADIATION SAFETY (CAIRS): Listings for 1985

1. CAIRS Annual Report, March 31, 1985.

2. "Determination of the contribution of long-lived dust to the committed dose equivalent received by uranium mine and mill workers in the Elliot Lake area", report on research completed under contract to the Atomic Energy Control Board of Canada, November 1985.

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JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

APPENDIX

DATE	STATEMENT OF PROJECT	PROJECT #

TITLE	MATRIX LOCATION

OBJECTIVE

SCOPE OF WORK	ANTICIPATED COST

RESEARCHER(S)	ANTICIPATED COMPLETION DATE

SPONSOR(S)	CONTACT

FORM 1/84

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

DATE	REPORT ON PROJECT PROGRESS	PROJECT #

TITLE	MATRIX LOCATION

PROGRESS/STATUS

CHANGES	ANTICIPATED COST ANTICIPATED COMPLETION DATED

SPONSOR(S)	CONTACT

FORM 2/84

JOINT PANEL ON OCCUPATIONAL AND ENVIRONMENTAL RESEARCH
FOR URANIUM PRODUCTION IN CANADA

DATE	PROJECT COMPLETION REPORT	PROJECT #

TITLE	MATRIX LOCATION

DISPOSITION/STATUS

(Please quote abstract of publication if appropriate)

PUBLICATION AVAILABILITY	FINAL COST

SPONSOR(S)	CONTACT

FORM 3/84